

Utilization of Low NO_x Coal Combustion By-Products

**Quarterly Report
July - September 1995**

November 1995

Work Performed Under Contract No.: DE-FC21-94MC31174

For
U.S. Department of Energy
Office of Fossil Energy
Morgantown Energy Technology Center
Morgantown, West Virginia

By
Michigan Technological University
Houghton, Michigan

MASTER

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BY-PRODUCTS

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P.O. Box 880
Morgantown, West Virginia 26507-0880

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1400 Townsend Drive
Houghton, Michigan 49931

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PROJECT SUMMARY - FOURTH QUARTER

July 1 through September 30, 1995

PROJECT SUMMARY

The first year of the project has been successfully completed. Three ash samples have been processed in the pilot plant, providing samples for the utilization tasks. The concrete task is nearly complete and efforts are underway to evaluate market potential and ash suitability for use in related concrete products such as block, aggregate, and aerated autoclaved concrete. Use of ash as a filler in plastics has attracted attention from a nationwide filler supplier. The task to evaluate the carbon products is just getting underway, with the preliminary market study indicating that wastewater sorbent applications may be the best way to go with this product.

Moving the project into a third or demonstration phase has been discussed with several utilities, including Detroit Edison and American Electric Power. The feedback has been very favorable.

TASK 1.0 Test Plan

This task has been completed.

TASK 2.0 Laboratory Characterization

TASK 2.1 Sample Collection

In addition to the samples previously obtained from American Electric Power, Baltimore Gas & Electric, Nevada Power Company, and Detroit Edison, a new sample of Class F fly ash from Consumers Power Company's Campbell Station in West Olive, Michigan was obtained.

TASK 2.2 Material Characterization

Screen analyses and Microtrac measurements were determined for the various pilot plant products for AEP, NPC, and BGE ash. The Microtrac analyses were done on the -400mesh fraction from the sieve analyses. The AEP analyses were run on samples from pilot run #4. The complete results are included in Appendix A. A summary of the sieve analyses showing the amount coarser than 325 mesh (percent retained on a 325 mesh sieve) for the various components of each ash is given in Table 1.

Table 1. Percent Retained on 325 mesh (44 micron)

<u>Component</u>	<u>AEP</u>	<u>BGE</u>	<u>NPC</u>
clean ash	22.3	22.1	33.2
cenospheres	90.6	92.2	84.1
magnetics	28.3	40.2	32.1
carbon	54.7	17.4	29.8

Both the AEP and BGE clean ash samples are quite fine, the NPC clean ash is slightly coarser. The cenospheres from all the ash samples are significantly coarser than any of the other components. The size distributions of the magnetic and carbon fractions vary widely between ash samples.

The specific gravity of the various fly ash components was determined from pilot plant samples (AEP samples were from run #4). These results are given in Table 2.

Table 2. Specific Gravity of Fly Ash Components

<u>Ash Sample</u>	<u>Clean Ash</u>	<u>Carbon</u>	<u>Magnetics</u>
AEP	2.125	1.961	4.006
BGE	2.082	2.117	3.199
NPC	2.233	1.867	3.536

Magnetic susceptibility was measured for the magnetic component of the fly ash. The EMU/gram for the various magnetic components is given in Table 3.

Table 3. EMU Measurements of Magnetic Components

<u>Ash Sample - Magnetic Component</u>	<u>EMU/gram</u>
AEP	47.40
BGE	37.76
NPC	27.82
DE1	35.89
DE2	40.77

One possible application of the magnetic component of fly ash is as a heavy medium for density based separations. Typical commercially available magnetite has a specific gravity in the range of 4.6 to 5.0 and an EMU/gram in the range of 70 to 80. The fly ash magnetite is below these ranges.

TASK 2.3 Laboratory Testing of Ash Processing Operations

Laboratory Flotation Program

The laboratory flotation test program begun last quarter has been completed. This test program studied two ash samples - AEP representing a Class F ash and NPC representing a Class C ash. Flotation parameters studied were pulp density, conditioning time, collector type and dosage, frother type and dosage, and pH adjustment.

The data analysis is not complete for this test program, however, some observations can be made. For the NPC ash, the effect of pH adjustment on flotation results was not tested. Initial tests showed that it was difficult to bring the pH to neutral and to hold it there during the tests due to the high lime content of this ash. It was decided to eliminate pH adjustment as a variable for the NPC portion of the testing. For the AEP testing, using the target values of $\leq 2\%$ LOI and $\geq 50\%$ weight recovery in the clean ash, all of the acceptable tests were conducted at a natural pH level.

The raw data for the test program are given in Appendix B. The tests are sorted based on the cell product (clean ash) %LOI. For the AEP ash, the range of clean ash %LOI was quite broad, from 0.06% up to 24.96%. The flotation parameters included collector dosages of 8.5, 10.0, and 11.5 pounds of reagent per ton of fly ash (#/t); frother dosages of 0.83, 1.25, and 1.67 #/t; one or five minute conditioning times; percent solids of 10, 18, and 25%; and pH modification with NaOH to bring the pH up to 7 from 4.9.

For the NPC ash flotation program, the %Carbon was measured rather than the %LOI because constituents of Class C ash hydrate when placed in water resulting in an elevated LOI value. The range of %C values in the Class C clean ash was much narrower than the Class F ash, from 1.03 to 2.78%C. The initial carbon content was 4%C for this sample compared to over 25% LOI for the AEP sample. The flotation parameters included collector dosages of 5.93, 7.07, and 8.26 #/t; frother dosages of 0.87, 1.09, and 1.31 #/t; one and five minute conditioning times; and percent solids of 10, 18, and 25%. The natural pH of 11.5 was not modified for the NPC ash flotation tests.

Ancillary Operations Testing

Settling tests are being conducted to establish thickener requirements for both a Class F (AEP) and a Class C (NPC) clean ash and the associated carbon fractions. Tests are also being conducted using flocculants to possibly improve the settling rates.

Filtering tests are being carried out using both Class C and Class F clean ashes and the associated carbon fractions. Four different filter media will be tested with varying lengths of form and drying time being allowed for cake formation and dewatering.

Preliminary filtering tests were conducted at fixed form and dry times to evaluate the effect of using hot air or steam to improve the filtration and reduce the final cake moisture. Steam is used in industry to reduce the moisture content of the filter cake, in an effort to avoid or decrease thermal drying requirements. In this case, we are looking for moistures below 10%.

These tests were conducted use clean ash from AEP. Three different filter mediums were tested and each test was done in duplicate. The average percent moisture obtained for each condition is given in Table 4.

Table 4. Percent Moisture for AEP Clean Ash Using Various Filter Mediums and Conditions

<u>Media</u>	<u>Ambient Air (90°F)</u>	<u>Hot Air (410°F)</u>	<u>Steam (300°F)</u>
POPR-851	17.11	17.01	14.90
POPR-858	21.01	18.58	16.46
CO-12	17.98	16.98	16.89

These tests show that the use of hot air or steam can reduce the final cake moistures, however the final moistures are still too high to eliminate thermal processing. If ambient air filtration could reduce the moisture to 11 - 12%, the addition of hot air or steam to the process could be enough to allow elimination of the thermal drying.

A fly ash sample has been sent to Heinkel Filtering Systems. They will provide us with an assessment of their filter/centrifuge system and its performance in dewatering fly ash. The Heinkel filter/centrifuge system may be capable of reducing the clean ash moisture to below 10%, which may allow us to eliminate the thermal drying portion of the process. Using mechanical dewatering and avoiding thermal processing can decrease overall capital costs. In addition, operating costs will decrease significantly - up to 40% - by reducing the energy/fuel costs associated with thermal drying.

A perforated bowl for the existing AML centrifuge has been ordered. This will give us the option of conducting various dewatering tests on the different ash components here in our pilot plant.

TASK 3.0 Pilot Plant Testing

No pilot plant tests were conducted during this quarter.

TASK 4.0 Product Testing

TASK 4.1 Concrete Testing

The concrete strength testing is nearly complete for all the as-received and cleaned fly ash samples. The compiled data will be reported next quarter.

TASK 4.2 Concrete Block/Brick

This task was not underway in this quarter.

TASK 4.3 Plastic Fillers

There were two primary achievements in this task during the fourth quarter. First, air classification was used to successfully separate 3.3 kg of material with a mean particle size of less than five microns from the AEP clean ash. Second, it was determined that impurities leaching from the fly ash were the primary cause of the off-white ZnO coating on the fly ash.

An Acucut A-12 air classifier was used for the air classification work. It was necessary to install several parts and a new speed controller. The classifier was tested under various operating parameters including flow rate and rotation speed. These results, showing the percentage reporting to either the coarse or fine fraction and the mean particle size of each fraction, are given in Table 5. The size distributions for the coarse and fine fraction from each test are given in Appendix C.

Table 5. Air Classifier Test Results

<u>Test No.</u>	<u>Flow Rate (SCFM)</u>	<u>Rotation (RPM)</u>	<u>Coarse Fraction</u>	<u>Fine Fraction</u>
4	45	1800	95.4%, 28.1 μ	4.62%, 3.45 μ
5	55	1800	94.6%, 35.1 μ	5.37%, 2.95 μ
6	65	1800	92.2%, 33.1 μ	7.77%, 3.13 μ
7	45	1000	86.1%, 39.6 μ	13.9%, 4.25 μ
8	45	2000	97.9%, 36.2 μ	2.09%, 2.61 μ
9	45	3000	99.3%, 29.0 μ	0.74%, 2.71 μ
10	55	1000	83.3%, 38.3 μ	16.7%, 4.13 μ
11	65	1000	82.3%, 37.7 μ	17.7%, 4.65 μ
12	not adjusted	1000	88.9%, 37.3 μ	11.1%, 21.2 μ

Test 10, with a flow rate of 55 SCFM and a rotation speed of 1000 RPM, produced the desired results. The mean particle size is 4.13 microns and the yield rate of fine particles was 16.7% of the total feed. These operating parameters were used to produce fine fly ash for the plastic filler test. Clean fly ash from pilot run #4 from AEP was fed through the air classifier until more than three kilograms of fine material had been generated. The particle size and distribution of the resulting ash was measured again after classification. The mean particle size was about four microns, with a narrow size distribution ranging from 2.8 to 7.8 microns. Table 6 shows the size distribution of two samples randomly taken from the fine clean ash fraction.

Table 6. Fine clean ash fraction size distributions

Sample 1			Sample 2		
Channel	Cum % Passing	Volume	Channel	Cum % Passing	Volume
22	100	0	22	100	0
16	100	0.8	16	100	1.6
11	99.2	5.1	11	98.4	6.1
7.8	94.2	13.8	7.8	92.4	15.3
5.5	80.4	21.0	5.5	77.1	22.1
3.9	59.4	24.0	3.9	55.0	22.3
2.8	35.4	19.9	2.8	32.7	18.2
1.9	15.4	8.3	1.9	14.5	7.8
1.4	7.1	5.2	1.4	6.7	4.9
0.9	1.9	1.9	0.9	1.8	1.8
mean volume: 3.96			mean volume: 4.19		

Previous tests using a ZnO coating did not generate white fly ash particles. Two possible reasons for off-white color of the coating were impurity contamination from the fly ash and/or insufficient thickness of the ZnO coating. To test the coating thickness, a multilayer coating of ZnO was applied. The fly ash particles were grown from an initial size of about 20 microns to a few hundred microns by coating with ZnO, but there was no improvement in the brightness.

A comparison test of pure ZnO precipitation was conducted using a steel impeller or a polymer coated magnetic bar stirrer. The ZnO precipitates formed when using the polymer coated magnetic stirrer were brighter than those formed when using the steel impeller to stir the material. This indicated contamination from the steel propeller. A leaching test, conducted by adding various amounts of HCl to the fly ash slurry resulted in a yellowish solution. Chemical analyses of these solutions revealed that many elements are acid leachable from fly ash. Table 7 shows the ICP analytical results from the leach solutions. The current pH of the coating slurry is about 6.1, so some materials could be leaching out of the fly ash and into the ZnO coating. It was also determined holding the slurry for a long settling time after coating resulted in a less bright coated fly ash. For these reasons, we concluded

that many elements in the fly ash can be leached out to contaminate the ZnO coating, resulting in the off-white color.

Table 7. Leaching Test Results

Element	Content in Leaching Solution, ppm		
	<u>X1FLY</u>	<u>X2FLY</u>	<u>X3FLY</u>
Si	66.4	65.2	66.9
Mg	23.7	28.2	25.4
Mn	0.72	0.74	0.76
Pb	1.21	1.20	1.23
Ba	8.08	8.34	8.84
K	32.8	35.1	37.0
Na	6.46	6.83	7.83
Ni	0.78	0.78	0.90
Al	273.9	285.6	288.6
Ca	88.5	95.3	89.1
Fe	84.8	91.9	86.5
Zn	3.88	3.87	2.05
Cu	1.42	1.52	1.45
P	10.3	10.3	10.6

TASK 4.4 Activated Carbon

This task was not underway in this quarter.

TASK 5.0 Market and Economic Analysis

Previously, three market areas - cement and concrete, fillers in plastics, and activated carbon and carbon black - had been identified as the targets for the beneficiated fractions of low NO_x fly ash. During this quarter, marketing efforts were focused on obtaining details on viable aspects of the various markets and establishing contacts with marketing representatives of the sectors.

Cement and Concrete Markets

The use of fly ash by the cement industry is well documented. Even though the cement market is large, it is likely to satisfy its need for fly ash from current sources for the near term. The concrete product and aggregate markets are closely related to cement and investigations are underway to determine their suitability to consume significant amounts of fly ash.

Cement products typically use some form of aggregate to enhance properties such as strength. Typically, aggregates are prepared from gravel or from crushed limestone rock. Artificial aggregates can be prepared from fly ash by several processes including sintering and cold bonding. Since certain areas of the country are known to be aggregate poor and power plants are generally located in the proximity of construction activity that requires aggregates, appreciable market potential exists for engineered aggregates made from fly ash.

A summary of fly ash aggregate manufacturing processes is being prepared, including process descriptions, ash requirements, and plant sizes and costs. Processing by sintering and cold bonding will be compared.

A related product being explored is aerated autoclaved concrete (ACC). This product is widely used in Europe and is made by adding aluminum powder to a cement or fly ash slurry. The subsequent release of hydrogen creates a porous structure material that is easily cut into building panels or blocks.

Fillers in Plastics

In additions to the technical work with fly ash fillers in high and low density polyethylene and in polypropylene, arrangements have been made with an automotive industry engineered plastics company to supply the project twenty two commercial resins for evaluation.

The effort to commercialize the results of the project is being enhanced by locating commercial suppliers of fillers for plastic resins. Discussions with one national supplier is leading to an agreement to evaluate the recovered fly ash fractions in their laboratories. The company processes mineral based materials for a wide variety of industrial applications and distributes them through a national system.

Activated Carbon and Carbon Black

Initial laboratory results indicate activated carbon produced from fly ash recovered carbon will likely have an activation level less than half that of commercially available carbons. This limits the use of fly ash carbon to applications where the carbon is primarily used once then discarded. These include

situations where regeneration of the carbon is not generally practiced because:

1. regulations dictate sealed disposal of the adsorbed waste,
2. the objective is to clean a gas or water stream and discard the adsorbed compounds.

These conditions are met with applications for activated carbon where regeneration is either difficult, inefficient, or forbidden. These applications favor an adsorbent with the most favorable price efficiency as measured by adsorbed quantity per unit cost of adsorbent.

Likely applications for appreciable quantities of fly ash derived carbon under the previously described conditions are oil refining and similar scrubber processes. Discussions have been initiated with commercial representatives of the activated and general carbon industry to locate niche applications for fly ash derived carbon. These efforts will continue with a focus on the refining industry.

Commercial Demonstration

During the last quarter, the market development efforts have also begun to focus on developing a commercial demonstration of fly ash beneficiation. Likely participants, in addition to the Institute of Materials Processing, include a coal burning electric utility and marketer(s) of mineral fillers and carbon. The potential plant would be of sufficient size to evaluate process economics and to supply customers beneficiated products in sufficient quantity to conduct meaningful production and market evaluations.

APPENDIX A

CHARACTERIZATION INFORMATION

AEP Clean Ash

Sieve Analysis				Microtrac Analysis of -400 mesh fraction		
<u>Tyler Mesh</u>	<u>Weight (grams)</u>	<u>Individual Wt% Retained</u>	<u>Cumulative Wt% Retained</u>	<u>Channel (microns)</u>	<u>Cumulative % Passing</u>	<u>Volume % Passing</u>
+100	0.0	0.00	0.00	88	100.0	0.1
				62	99.9	4.3
				44	95.5	12.1
+150	0.6	1.36	1.36	31	83.5	14.7
				22	68.8	14.3
+200	2.4	5.45	6.82	16	54.5	13.9
				11	40.6	11.8
+270	2.8	6.36	13.18	7.8	28.8	9.4
				5.5	19.4	6.6
+325	4.0	9.09	22.27	3.9	12.7	5.4
				2.8	7.4	4.8
+400	3.2	7.27	29.55	1.9	2.6	1.7
				1.4	0.8	0.8
-400	31.0	70.45	100.0	0.9	0.0	0

AEP Cenospheres

Sieve Analysis				Microtrac Analysis of -400 mesh fraction		
<u>Tyler Mesh</u>	<u>Weight (grams)</u>	<u>Individual Wt% Retained</u>	<u>Cumulative Wt% Retained</u>	<u>Channel (microns)</u>	<u>Cumulative % Passing</u>	<u>Volume % Passing</u>
+100	2.2	5.73	5.73	88	100.0	0.2
				62	99.8	7.9
				44	91.8	23.8
+150	10.8	28.13	33.85	31	68.1	24.7
				22	43.4	13.3
+200	11.0	28.65	62.50	16	30.1	8.7
				11	21.4	7.1
+270	6.8	17.71	80.21	7.8	14.3	5.5
				5.5	8.7	3.7
+325	4.0	10.42	90.63	3.9	5.0	2.5
				2.8	2.5	2.0
+400	1.2	3.13	93.75	1.9	0.4	0.4
				1.4	0.0	0.0
-400	2.4	6.25	100.0	0.9	0.0	0.0

AEP Magnetics

Sieve Analysis				Microtrac Analysis of -400 mesh fraction		
<u>Tyler Mesh</u>	<u>Weight (grams)</u>	<u>IndividualWt% Retained</u>	<u>CumulativeWt% Retained</u>	<u>Channel (microns)</u>	<u>Cumulative % Passing</u>	<u>Volume % Passing</u>
				88	100.0	2.8
+100	0.0	0.00	0.00	62	97.2	10.7
				44	86.5	21.4
+150	0.6	0.96	0.96	31	65.1	22.6
				22	42.5	17.1
+200	2.6	4.18	5.14	16	25.4	11.7
				11	13.8	6.9
+270	5.2	8.36	13.50	7.8	6.9	3.9
				5.5	3.0	2.1
+325	9.2	14.79	28.30	3.9	0.9	0.8
				2.8	0.1	0.1
+400	6.8	10.93	39.23	1.9	0.0	0.0
				1.4	0.0	0.0
-400	37.8	60.77	100.0	0.9	0.0	0.0

AEP Carbon

Sieve Analysis				Microtrac Analysis of -400 mesh fraction		
<u>Tyler Mesh</u>	<u>Weight (grams)</u>	<u>IndividualWt% Retained</u>	<u>CumulativeWt% Retained</u>	<u>Channel (microns)</u>	<u>Cumulative % Passing</u>	<u>Volume % Passing</u>
				88	100.0	1.6
+100	0.0	0.00	0.00	62	98.4	8.9
				44	89.5	19.1
+150	1.4	4.29	4.29	31	70.4	19.4
				22	50.9	14.4
+200	5.6	17.18	21.47	16	36.5	11.3
				11	25.3	7.9
+270	5.4	16.56	38.04	7.8	17.4	6.0
				5.5	11.4	4.6
+325	5.4	16.56	54.68	3.9	6.8	3.7
				2.8	3.1	2.7
+400	3.0	9.20	63.80	1.9	0.5	0.5
				1.4	0.0	0.0
-400	11.8	36.20	100.0	0.9	0.0	0.0

BGE Clean Ash

Sieve Analysis				Microtrac Analysis of -400 mesh fraction		
<u>Tyler Mesh</u>	<u>Weight (grams)</u>	<u>IndividualWt% Retained</u>	<u>CumulativeWt% Retained</u>	<u>Channel (microns)</u>	<u>Cumulative % Passing</u>	<u>Volume % Passing</u>
				88	100.0	0.0
+100	0.0	0.00	0.00	62	100.0	4.5
				44	95.5	13.6
+150	0.6	1.20	1.20	31	81.9	18.3
				22	63.6	18.4
+200	2.4	4.82	6.02	16	45.2	16.2
				11	29.1	11.1
+270	3.0	6.02	12.05	7.8	18.0	6.8
				5.5	11.1	4.1
+325	5.0	10.04	22.09	3.9	7.1	3.1
				2.8	4.0	2.8
+400	3.8	7.63	29.72	1.9	1.2	0.9
				1.4	0.3	0.3
-400	35.0	70.28	100.0	0.9	0.0	0.0

BGE Cenospheres

Sieve Analysis				Microtrac Analysis of -400 mesh fraction		
<u>Tyler Mesh</u>	<u>Weight (grams)</u>	<u>IndividualWt% Retained</u>	<u>CumulativeWt% Retained</u>	<u>Channel (microns)</u>	<u>Cumulative % Passing</u>	<u>Volume % Passing</u>
				88	100.0	0.0
+100	1.8	5.39	5.39	62	100.0	4.5
				44	95.5	17.4
+150	9.2	27.54	32.93	31	78.2	19.6
				22	58.6	12.7
+200	10.8	32.34	65.27	16	45.9	11.2
				11	34.7	10.9
+270	6.2	18.56	83.83	7.8	23.8	8.4
				5.5	15.4	5.5
+325	2.8	8.38	92.22	3.9	9.9	4.6
				2.8	5.4	3.9
+400	0.8	2.40	94.61	1.9	1.4	1.1
				1.4	0.3	0.3
-400	1.8	5.39	100.0	0.9	0.0	0.0

BGE Magnetics

Sieve Analysis				Microtrac Analysis of -400 mesh fraction		
<u>Tyler Mesh</u>	<u>Weight (grams)</u>	<u>Individual Wt% Retained</u>	<u>Cumulative Wt% Retained</u>	<u>Channel (microns)</u>	<u>Cumulative % Passing</u>	<u>Volume % Passing</u>
				88	99.7	3.1
+100	2.6	2.03	2.03	62	96.5	9.5
				44	87.1	19.7
+150	4.0	3.13	5.16	31	67.4	21.8
				22	45.6	17.0
+200	9.0	7.04	12.21	16	28.5	12.1
				11	16.4	7.4
+270	14.6	11.42	23.63	7.8	9.0	4.6
				5.5	4.4	2.5
+325	21.2	16.59	40.22	3.9	1.9	1.2
				2.8	0.7	0.7
+400	13.6	10.64	50.86	1.9	0.0	0.0
				1.4	0.0	0.0
-400	62.8	49.14	100.0	0.9	0.0	0.0

BGE Carbon

Sieve Analysis				Microtrac Analysis of -400 mesh fraction		
<u>Tyler Mesh</u>	<u>Weight (grams)</u>	<u>Individual Wt% Retained</u>	<u>Cumulative Wt% Retained</u>	<u>Channel (microns)</u>	<u>Cumulative % Passing</u>	<u>Volume % Passing</u>
				88	100.0	0.0
+100	0.0	0.00	0.00	62	100.0	1.3
				44	98.7	5.9
+150	0.8	1.52	1.52	31	92.8	7.6
				22	85.2	8.6
+200	2.6	4.92	6.44	16	76.6	10.8
				11	65.8	11.9
+270	2.4	4.55	10.98	7.8	53.9	13.5
				5.5	40.4	12.0
+325	3.4	6.44	17.42	3.9	28.5	11.5
				2.8	17.0	10.3
+400	2.6	4.92	22.35	1.9	6.7	3.9
				1.4	2.8	2.3
-400	41.0	77.65	100.0	0.9	0.5	0.5

NPC Clean Ash

Sieve Analysis				Microtrac Analysis of -400 mesh fraction		
<u>Tyler Mesh</u>	<u>Weight (grams)</u>	<u>IndividualWt% Retained</u>	<u>CumulativeWt% Retained</u>	<u>Channel (microns)</u>	<u>Cumulative % Passing</u>	<u>Volume % Passing</u>
				88	100.0	0.0
+100	0.4	0.75	0.75	62	100.0	3.2
				44	96.8	9.7
+150	0.6	1.12	1.87	31	87.1	12.2
				22	74.9	12.1
+200	3.4	6.34	8.21	16	62.8	12.2
				11	50.6	10.6
+270	6.2	11.57	19.78	7.8	40.0	9.4
				5.5	30.5	7.6
+325	7.2	13.43	33.21	3.9	22.9	8.4
				2.8	14.5	8.4
+400	4.6	8.58	41.79	1.9	6.1	3.5
				1.4	2.6	2.1
-400	31.2	58.21	100.0	0.9	0.5	0.5

NPC Cenospheres

Sieve Analysis				Microtrac Analysis of -400 mesh fraction		
<u>Tyler Mesh</u>	<u>Weight (grams)</u>	<u>IndividualWt% Retained</u>	<u>CumulativeWt% Retained</u>	<u>Channel (microns)</u>	<u>Cumulative % Passing</u>	<u>Volume % Passing</u>
				88	100.0	0.0
+100	4.4	12.94	12.94	62	100.0	0.7
				44	99.3	6.2
+150	7.6	22.35	35.29	31	93.1	9.4
				22	83.7	10.6
+200	9.0	26.47	61.76	16	73.1	13.7
				11	59.4	15.0
+270	5.4	15.88	77.65	7.8	44.4	13.3
				5.5	31.1	10.0
+325	2.2	6.47	84.12	3.9	21.1	8.6
				2.8	12.4	7.7
+400	0.6	1.76	85.88	1.9	4.8	2.9
				1.4	1.8	1.6
-400	4.8	14.12	100.0	0.9	0.2	0.2

NPC Magnetics

Sieve Analysis				Microtrac Analysis of -400 mesh fraction		
<u>Tyler Mesh</u>	<u>Weight (grams)</u>	<u>Individual Wt% Retained</u>	<u>Cumulative Wt% Retained</u>	<u>Channel (microns)</u>	<u>Cumulative % Passing</u>	<u>Volume % Passing</u>
+100	1.0	2.01	2.01	88	100.0	0.0
+150	1.6	3.21	5.22	62	100.0	3.2
+200	3.0	6.02	11.24	44	96.8	13.6
+270	4.0	8.03	19.28	31	83.2	19.6
+325	6.4	12.85	32.13	22	63.6	18.4
+400	5.0	10.04	42.17	16	45.2	15.2
-400	28.8	57.83	100.0	11	30.0	11.0
				7.8	19.1	7.8
				5.5	11.3	5.4
				3.9	5.9	3.4
				2.8	2.5	2.2
				1.9	0.3	0.3
				1.4	0.0	0.0
				0.9	0.0	0.0

NPC Carbon

Sieve Analysis				Microtrac Analysis of -400 mesh fraction		
<u>Tyler Mesh</u>	<u>Weight (grams)</u>	<u>Individual Wt% Retained</u>	<u>Cumulative Wt% Retained</u>	<u>Channel (microns)</u>	<u>Cumulative % Passing</u>	<u>Volume % Passing</u>
+100	0.2	0.56	0.56	88	100.0	0.9
+150	1.0	2.81	3.37	62	99.1	3.1
+200	2.4	6.74	10.11	44	96.0	7.7
+270	2.8	7.87	17.98	31	88.3	10.3
+325	4.2	11.80	29.78	22	78.0	10.8
+400	2.2	6.18	35.96	16	67.2	11.2
-400	22.8	64.04	100.0	11	56.0	10.4
				7.8	45.6	9.7
				5.5	36.0	8.5
				3.9	27.4	10.7
				2.8	16.8	10.1
				1.9	6.7	3.9
				1.4	2.8	2.3
				0.9	0.5	0.5

APPENDIX B

FLOTATION PROGRAM TEST RESULTS

FLOTATION PROGRAM DATA

TEST No.	IMP No.	Ash Type	Froth %WT	Froth %LOI	Rec. Cell %WT	Cell %LOI	Col #/T	Froth #/T	Cond Time (m)	% Sol	pH Modifier	Dosage		
232332	54	AEP	61.25	43.14	99.91	38.75	0.06	0.09	11.5	1.67	5	25.0	NA	NA
222331	90	AEP	56.61	45.95	99.80	43.49	0.12	0.20	11.5	1.67	5	18.0	NaOH	5.0
232232	51	AEP	59.89	44.05	99.82	40.11	0.12	0.18	10.0	1.67	5	25.0	NA	NA
232331	108	AEP	40.40	42.73	99.21	40.40	0.23	0.79	11.5	1.67	5	25.0	NaOH	7.0
232132	48	AEP	58.28	44.67	99.58	41.72	0.26	0.42	8.5	1.67	5	25.0	NA	NA
222221	86	AEP	54.16	48.95	99.47	45.84	0.31	0.53	10.0	1.25	5	18.0	NaOH	5.5
222217	33	AEP	54.96	48.22	99.48	45.04	0.31	0.52	10.0	1.67	5	18.0	NA	NA
227322	35	AEP	54.45	48.78	99.35	45.55	0.38	0.65	11.5	1.25	5	18.0	NA	NA
212332	18	AEP	49.58	51.73	99.18	50.42	0.42	0.82	11.5	1.67	5	10.0	NA	NA
222222	32	AEP	48.39	51.22	99.13	51.61	0.42	0.87	10.0	1.25	5	18.0	NA	NA
232231	105	AEP	53.08	41.39	99.03	46.92	0.46	0.97	10.0	1.67	5	25.0	NaOH	7.0
222132	30	AEP	55.71	46.89	99.19	44.29	0.48	0.81	8.5	1.67	5	18.0	NA	NA
222332	36	AEP	56.08	46.91	99.17	43.92	0.50	0.83	11.5	1.67	5	18.0	NA	NA
212231	69	AEP	54.16	46.29	99.06	45.84	0.52	0.94	10.0	1.67	5	10.0	NaOH	2.5 ml
222231	87	AEP	54.87	45.92	99.08	45.13	0.52	0.92	10.0	1.67	5	18.0	NaOH	5.5
212322	17	AEP	47.07	53.90	98.91	52.93	0.53	1.09	11.5	1.25	5	10.0	NA	NA
232322	53	AEP	56.32	45.92	99.06	43.68	0.56	0.94	11.5	1.25	5	25.0	NA	NA
212331	72	AEP	58.59	42.08	98.97	41.41	0.62	1.03	11.5	1.67	5	10.0	NaOH	2.5
221331	81	AEP	57.72	49.35	99.02	42.28	0.67	0.98	11.5	1.67	1	18.0	NaOH	6.5
212131	66	AEP	52.12	48.83	98.70	47.88	0.70	1.30	8.5	1.67	5	10.0	NaOH	2.5
212132	12	AEP	47.44	53.27	98.52	52.56	0.72	1.48	8.5	1.67	5	10.0	NA	NA
222131	84	AEP	50.65	49.15	98.42	49.35	0.81	1.58	8.5	1.67	5	18.0	NaOH	6.0
212232	15	AEP	46.45	52.72	98.07	53.55	0.90	1.93	10.0	1.67	5	10.0	NA	NA
222321	89	AEP	53.22	49.80	98.42	46.78	0.91	1.58	11.5	1.25	5	18.0	NaOH	5.0
211331	63	AEP	58.61	41.46	98.33	41.39	1.00	1.67	11.5	1.67	1	10.0	NaOH	2.5
232321	107	AEP	55.94	46.94	98.30	44.06	1.03	1.70	11.5	1.25	5	25.0	NaOH	7.0
212122	11	AEP	43.60	58.37	97.49	56.40	1.16	2.51	8.5	1.25	5	10.0	NA	NA
212222	14	AEP	44.75	56.60	97.30	55.25	1.27	2.70	10.0	1.25	5	10.0	NA	NA
232222	50	AEP	55.02	46.34	97.79	44.98	1.28	2.21	10.0	1.25	5	25.0	NA	NA
212121	65	AEP	50.34	48.67	97.32	49.66	1.36	2.68	8.5	1.25	5	10.0	NaOH	2.5
231332	45	AEP	58.10	44.29	97.71	41.90	1.44	2.29	11.5	1.67	1	25.0	NA	NA
212221	68	AEP	51.09	47.22	97.07	48.91	1.49	2.93	10.0	1.25	5	10.0	NaOH	2.5
221332	27	AEP	57.13	45.23	97.26	42.87	1.70	2.74	11.5	1.67	1	18.0	NA	NA
211231	60	AEP	51.42	49.53	96.70	48.58	1.79	3.30	10.0	1.67	1	10.0	NaOH	3.0
221237	24	AEP	53.93	47.12	96.86	46.07	1.79	3.14	10.0	1.67	1	18.0	NA	NA
232122	47	AEP	53.27	46.01	96.63	46.73	1.83	3.37	8.5	1.25	5	25.0	NA	NA
211332	9	AEP	47.53	52.00	96.18	52.47	1.87	3.82	11.5	1.67	1	10.0	NA	NA
232221	104	AEP	50.63	48.47	96.30	49.37	1.91	3.70	10.0	1.25	5	25.0	NaOH	7.0
211322	8	AEP	45.59	53.78	94.76	54.41	2.49	5.24	11.5	1.25	1	10.0	NA	NA
222317	34	AEP	46.69	52.53	94.79	53.31	2.53	5.21	11.5	0.83	5	18.0	NA	NA
222127	29	AEP	47.94	52.16	93.68	52.06	3.24	6.32	8.5	1.25	5	18.0	NA	NA
212231	78	AEP	52.73	47.49	94.00	47.27	3.38	6.00	10.0	1.67	1	18.0	NaOH	6.5
232131	102	AEP	55.47	45.61	94.20	44.53	3.50	5.80	8.5	1.67	5	25.0	NaOH	7.0
222121	83	AEP	47.70	50.67	92.00	52.30	4.02	8.00	8.5	1.25	5	18.0	NaOH	6.5
211321	62	AEP	52.03	46.09	92.40	47.97	4.11	7.60	11.5	1.25	1	10.0	NaOH	2.5
211232	6	AEP	43.73	55.17	91.17	56.27	4.15	8.83	10.0	1.67	1	10.0	NA	NA
221221	77	AEP	39.05	50.90	88.18	60.95	4.37	11.82	10.0	1.25	1	18.0	NaOH	5.5
212112	16	AEP	39.56	57.41	88.26	60.44	5.00	11.74	11.5	0.83	5	10.0	NA	NA
211131	57	AEP	49.08	47.08	89.61	50.92	5.26	10.39	8.5	1.67	1	10.0	NaOH	3.0
231232	42	AEP	51.90	45.47	89.41	48.10	5.81	10.59	10.0	1.67	1	25.0	NA	NA
231231	96	AEP	54.46	44.26	89.56	45.54	6.17	10.44	10.0	1.67	1	25.0	NaOH	7.0
221322	76	AEP	50.84	47.26	87.85	49.16	6.76	12.15	11.5	1.25	1	18.0	NA	NA
232121	101	AEP	46.43	47.77	84.96	53.57	7.33	15.04	8.5	1.25	5	25.0	NaOH	7.0
231132	39	AEP	50.88	44.75	86.17	49.12	7.44	13.83	8.5	1.67	1	25.0	NA	NA
231322	44	AEP	47.68	46.05	84.91	52.32	7.46	15.09	11.5	1.25	1	25.0	NA	NA
232312	52	AEP	44.15	50.00	83.43	55.85	7.85	16.57	11.5	0.83	5	25.0	NA	NA
231321	98	AEP	51.18	44.50	85.40	48.82	7.98	14.60	11.5	1.25	1	25.0	NaOH	7.0
212311	70	AEP	42.06	49.51	80.64	57.94	8.63	19.36	11.5	0.83	5	10.0	NaOH	2.5
232712	49	AEP	40.27	50.87	79.54	59.73	8.82	20.46	10.0	0.83	5	25.0	NA	NA
211132	3	AEP	33.06	57.43	73.87	66.94	10.03	26.13	8.5	1.67	1	10.0	NA	NA
222212	31	AEP	37.74	53.74	74.90	62.26	10.92	25.10	10.0	0.83	5	18.0	NA	NA
231131	93	AEP	48.18	44.62	78.65	51.82	11.26	21.35	8.5	1.67	1	25.0	NaOH	7.0
221222	23	AEP	43.85	46.32	76.21	56.15	11.29	23.79	10.0	1.25	1	18.0	NA	NA
232111	100	AEP	39.03	49.01	72.28	60.97	12.03	27.72	8.5	0.83	5	25.0	NaOH	7.0
222311	88	AEP	33.67	50.99	67.80	66.33	12.29	32.20	11.5	0.83	5	18.0	NaOH	5.0
232311	106	AEP	34.72	50.56	67.31	65.28	13.06	32.69	11.5	0.83	5	25.0	NaOH	7.0
221131	75	AEP	39.64	45.66	69.42	60.36	13.21	30.58	8.5	1.67	1	18.0	NaOH	7.0
221132	21	AEP	43.26	47.23	73.12	56.74	13.24	26.88	8.5	1.67	1	18.0	NA	NA
231221	95	AEP	39.97	46.02	69.80	60.03	13.26	30.20	10.0	1.25	1	25.0	NaOH	7.0
231222	41	AEP	63.40	48.25	85.62	36.60	14.04	14.38	10.0	1.25	1	25.0	NA	NA
231331	99	AEP	43.67	44.05	70.32	56.33	14.41	29.68	11.5	1.67	1	25.0	NaOH	7.0
212112	10	AEP	40.48	45.65	67.83	59.52	14.72	32.17	8.5	0.83	5	10.0	NA	NA
211221	59	AEP	37.82	46.09	65.02	62.18	15.08	34.98	10.0	1.25	1	10.0	NaOH	3.0
211122	2	AEP	28.50	57.29	59.49	71.50	15.55	40.51	8.5	1.25	1	10.0	NA	NA
212111	64	AEP	30.37	48.58	57.18	69.63	15.87	42.82	8.5	0.83	5	10.0	NaOH	2.5

FLOTATION PROGRAM DATA

TEST No.	IMP No.	Ash Type	Froth %Wt	Froth %LOI	Froth %LOI Rec.	Cell %Wt	Cell %LOI	Cell %LOI Rec.	Col %/T	Froth %/T	Cond Time) (m)	% Sol	pH Modifier	Dosage
231122	38	AEP	63.62	48.35	83.96	36.38	16.16	16.04	8.5	1.25	1	25.0	NA	NA
212321	71	AEP	28.62	52.22	56.29	71.38	16.26	43.71	11.5	1.25	5	10.0	NaOH	2.5
211311	61	AEP	30.77	46.01	54.96	69.23	16.76	45.04	11.5	0.83	1	10.0	NaOH	2.5
211222	5	AEP	26.32	54.04	53.37	73.68	16.86	46.63	10.0	1.25	1	10.0	NA	NA
211312	7	AEP	23.04	55.04	49.20	76.96	17.01	50.80	11.5	0.83	1	10.0	NA	NA
221312	25	AEP	33.33	46.24	57.34	66.67	17.20	42.66	11.5	0.83	1	18.0	NA	NA
232117	46	AEP	80.15	52.48	91.90	19.85	18.69	8.10	8.5	0.83	5	25.0	NA	NA
212212	13	AEP	19.73	57.34	42.67	80.27	18.94	57.33	10.0	0.83	5	10.0	NA	NA
222112	28	AEP	27.27	50.16	49.80	72.73	18.96	50.20	8.5	0.83	5	18.0	NA	NA
211121	56	AEP	31.26	41.02	49.29	68.74	19.19	50.71	8.5	1.25	1	10.0	NaOH	3.0
222211	85	AEP	21.98	50.68	42.59	78.02	19.24	57.41	10.0	0.83	5	18.0	NaOH	6.0
221311	79	AEP	26.93	46.36	46.81	73.07	19.42	53.19	11.5	0.83	1	18.0	NaOH	6.5
231121	97	AEP	28.67	46.05	48.72	71.33	19.48	51.28	8.5	1.25	1	25.0	NaOH	7.0
231312	43	AEP	24.91	45.21	42.67	75.09	20.15	57.33	11.5	0.83	1	25.0	NA	NA
212211	67	AEP	24.92	45.19	42.57	75.08	20.23	57.43	10.0	0.83	5	10.0	NaOH	2.5
211212	4	AEP	17.45	52.92	35.56	82.55	20.27	64.44	10.0	0.83	1	10.0	NA	NA
211211	58	ASP	20.94	47.12	37.85	79.06	20.49	62.15	10.0	0.83	1	10.0	NaOH	3.0
221212	22	AEP	15.10	52.57	31.09	84.90	20.72	68.91	10.0	0.83	1	18.0	NA	NA
232211	103	AEP	19.45	51.78	37.48	80.55	20.86	62.52	10.0	0.83	5	25.0	NaOH	7.0
221122	20	AEP	25.92	47.24	44.11	74.08	20.94	55.89	8.5	1.25	1	18.0	NA	NA
231311	97	ASP	24.78	45.14	41.25	75.22	21.18	58.75	11.5	0.83	1	25.0	NaOH	7.0 ml
221321	80	AEP	23.44	47.59	40.58	76.56	21.33	59.42	11.5	1.25	1	18.0	NaOH	6.5
221121	74	AEP	18.21	49.55	34.00	81.79	21.42	66.00	8.5	1.25	1	18.0	NaOH	6.7
231211	94	AEP	20.79	46.41	36.18	79.21	21.49	63.82	10.0	0.83	1	25.0	NaOH	7.0
211112	1	AEP	14.14	50.35	27.67	85.86	21.68	72.33	8.5	0.83	1	10.0	NA	NA
222111	82	AEP	17.74	51.12	33.52	82.26	21.87	66.48	8.5	0.83	5	18.0	NaOH	6.5
221211	76	ASP	14.65	44.03	25.03	85.35	22.64	74.97	10.0	0.83	1	18.0	NaOH	7.1
221111	73	ASP	17.59	43.93	29.21	82.41	22.72	70.79	8.5	0.83	1	18.0	NaOH	6.0
231111	91	AEP	16.29	45.58	28.07	83.71	22.73	71.93	8.5	0.83	1	25.0	NaOH	7.1
231212	40	AEP	77.65	45.50	87.24	22.35	23.13	12.76	10.0	0.83	1	25.0	NA	NA
221112	19	AEP	15.97	45.88	26.86	84.03	23.75	73.14	8.5	0.83	1	18.0	NA	NA
231112	37	AEP	84.06	46.41	90.78	15.94	24.86	9.22	8.5	0.83	1	25.0	NA	NA
211111	55	AEP	13.51	41.54	20.64	86.49	24.96	79.36	8.5	0.83	1	10.0	NaOH	2.5 ml

FLOTATION PROGRAM DATA

TEST	IMP	ASH	FROTH			CELL			COLL.	FROTH.	COND.	% SOL.	pH
NUM.	NUM.	TYPE	%WT.	% C	% C REC.	%WT.	% C	% C REC.	#/T	#/T	TIME (MIN)		
132332	54	NPC	33.50	8.10	79.83	66.50	1.03	20.17	8.26	1.31	5	25.0	natural
132322	53	NPC	31.11	8.33	78.40	68.89	1.04	21.60	8.26	1.09	5	25.0	natural
132312	52	NPC	31.51	8.66	77.07	68.49	1.19	22.93	8.26	0.87	5	25.0	natural
122332	36	NPC	29.79	8.45	74.84	70.21	1.21	25.16	8.26	1.31	5	18.0	natural
122322	35	NPC	28.39	8.73	74.05	71.61	1.21	25.95	8.26	1.09	5	18.0	natural
132212	49	NPC	27.59	8.47	71.96	72.41	1.26	28.04	7.07	0.87	5	25.0	natural
132222	50	NPC	30.36	7.86	72.73	69.64	1.28	27.27	7.07	1.09	5	25.0	natural
122232	33	NPC	25.12	9.10	69.70	74.88	1.33	30.30	7.07	1.31	5	18.0	natural
112332	18	NPC	24.92	8.22	66.70	75.08	1.36	33.30	8.26	1.31	5	10.0	natural
132232	51	NPC	32.64	7.91	73.68	67.36	1.37	26.33	7.07	1.31	5	25.0	natural
122312	34	NPC	25.14	8.92	66.57	74.86	1.50	33.43	8.26	0.87	5	18.0	natural
122222	32	NPC	22.42	10.20	65.77	77.58	1.53	34.23	7.07	1.09	5	18.0	natural
122212	31	NPC	20.97	9.64	61.22	79.03	1.62	38.78	7.07	0.87	5	18.0	natural
122132	30	NPC	25.09	8.01	62.18	74.91	1.63	37.82	5.93	1.31	5	18.0	natural
132132	48	NPC	24.97	9.80	66.00	75.03	1.68	34.00	5.93	1.31	5	25.0	natural
112232	15	NPC	23.09	9.24	62.23	76.91	1.68	37.77	7.07	1.31	5	10.0	natural
132122	47	NPC	27.63	7.84	63.93	72.38	1.69	36.07	5.93	1.09	5	25.0	natural
131232	42	NPC	29.80	6.77	63.06	70.20	1.69	36.94	7.07	1.31	1	25.0	natural
131332	45	NPC	32.51	6.39	64.33	67.49	1.71	35.67	8.26	1.31	1	25.0	natural
112322	17	NPC	23.26	9.03	61.23	76.74	1.73	38.77	8.26	1.09	5	10.0	natural
111332	9	NPC	23.76	7.21	55.81	76.22	1.78	44.19	8.26	1.31	1	10.0	natural
112222	14	NPC	24.75	8.28	59.68	75.25	1.84	40.32	7.07	1.09	5	10.0	natural
131322	44	NPC	28.72	6.62	58.60	71.28	1.88	41.40	8.26	1.09	1	25.0	natural
132112	46	NPC	22.29	9.29	58.36	77.71	1.90	41.64	5.93	0.87	5	25.0	natural
131132	39	NPC	29.31	6.67	58.90	70.69	1.93	41.10	5.93	1.31	1	25.0	natural
122122	29	NPC	20.81	8.40	53.09	79.19	1.95	46.91	5.93	1.09	5	18.0	natural
121332	27	NPC	24.77	7.45	54.91	75.23	2.01	45.09	8.26	1.31	1	18.0	natural
122112	28	NPC	20.29	8.58	52.02	79.71	2.02	47.98	5.93	0.87	5	18.0	natural
112132	12	NPC	21.14	8.82	53.43	78.86	2.06	46.57	5.93	1.31	5	10.0	natural
131122	38	NPC	29.31	6.52	56.69	70.69	2.07	43.31	5.93	1.09	1	25.0	natural
121232	24	NPC	26.78	6.79	54.47	73.22	2.08	45.53	7.07	1.31	1	18.0	natural
131222	41	NPC	30.87	6.01	56.25	69.13	2.09	43.75	7.07	1.09	1	25.0	natural
112212	13	NPC	22.96	6.94	49.52	77.04	2.11	50.48	7.07	0.87	5	10.0	natural
112122	11	NPC	20.40	8.53	50.73	79.60	2.12	49.27	5.93	1.09	5	10.0	natural
112312	16	NPC	24.92	7.25	53.20	75.08	2.12	46.80	8.26	0.87	5	10.0	natural
131112	37	NPC	22.47	7.14	48.91	77.53	2.16	51.09	5.93	0.87	1	25.0	natural
121322	26	NPC	22.73	7.57	50.37	77.27	2.20	49.63	8.26	1.09	1	18.0	natural
121222	23	NPC	22.36	7.14	48.33	77.64	2.20	51.67	7.07	1.09	1	18.0	natural
131312	43	NPC	25.22	7.65	53.63	74.78	2.23	46.37	8.26	0.87	1	25.0	natural
111322	8	NPC	22.58	7.03	47.72	77.42	2.24	52.28	8.26	1.09	1	10.0	natural
131212	40	NPC	22.70	7.94	50.27	77.30	2.31	49.73	7.07	0.87	1	25.0	natural
121312	25	NPC	19.76	7.88	45.28	80.24	2.35	54.72	8.26	0.87	1	18.0	natural
111232	6	NPC	23.05	6.90	46.00	76.95	2.43	54.00	7.07	1.31	1	10.0	natural
121122	20	NPC	21.42	7.14	44.36	78.58	2.44	55.64	5.93	1.09	1	18.0	natural
111132	3	NPC	20.51	6.87	41.88	79.49	2.46	58.12	5.93	1.31	1	10.0	natural
121132	21	NPC	21.52	6.79	42.80	78.48	2.49	57.20	5.93	1.31	1	18.0	natural
121212	22	NPC	20.24	6.92	40.91	79.76	2.54	59.09	7.07	0.87	1	18.0	natural
112112	10	NPC	25.64	6.29	46.09	74.38	2.54	53.91	5.93	0.87	5	10.0	natural
111122	2	NPC	22.24	6.30	41.30	77.76	2.56	58.70	5.93	1.09	1	10.0	natural
111312	7	NPC	22.32	6.16	40.90	77.68	2.56	59.10	8.26	0.87	1	10.0	natural
121112	19	NPC	17.45	7.09	36.84	82.55	2.57	63.16	5.93	0.87	1	18.0	natural
111112	1	NPC	25.04	5.31	40.85	74.96	2.57	59.15	5.93	0.87	1	10.0	natural
111222	5	NPC	22.58	6.58	42.23	77.42	2.62	57.77	7.07	1.09	1	10.0	natural
111212	4	NPC	24.41	5.74	40.03	75.59	2.78	59.97	7.07	0.87	1	10.0	natural

APPENDIX C

PLASTIC FILLER INFORMATION

Fly Ash Air Classification Test # 4

Fine Fraction			Coarse Fraction		
Channel (microns)	Cum. % Passing	Volume % Passing	Channel (microns)	Cum. % Passing	Volume % Passing
			176	100.0	0.0
			125	100.0	0.0
			88	100.0	8.7
			62	91.3	17.7
			44	73.6	10.2
			31	63.4	9.0
22	100.0	1.8	22	54.4	10.3
16	98.2	3.8	16	44.1	16.4
11	94.4	2.6	11	27.7	11.7
7.8	91.8	0.0	7.8	16.0	2.3
5.5	91.8	15.7	5.5	163.7	8.0
3.9	76.1	25.1	3.9	5.7	4.9
2.8	51.0	14.0	2.8	0.8	0.6
1.9	37.0	15.8	1.9	0.2	0.2
1.4	21.2	13.6	1.4	0.0	0.0
0.9	7.6	7.6	0.9	0.0	0.0

Fly Ash Air Classification Test # 5

Fine Fraction			Coarse Fraction		
Channel (microns)	Cum. % Passing	Volume % Passing	Channel (microns)	Cum. % Passing	Volume % Passing
			176	100.0	3.0
			125	97.0	5.1
			88	91.9	6.1
			62	85.7	14.0
			44	71.8	13.5
			31	58.2	11.1
22	100.0	0.0	22	47.1	9.1
16	100.0	0.0	16	38.0	11.8
11	100.0	0.0	11	26.2	11.8
7.8	100.0	3.7	7.8	14.4	2.9
5.5	96.3	11.1	5.5	11.5	6.0
3.9	85.2	35.2	3.9	5.5	4.8
2.8	50.0	32.1	2.8	0.7	0.5
1.9	17.9	10.2	1.9	0.2	0.2
1.4	7.7	5.8	1.4	0.0	0.0
0.9	1.9	1.9	0.9	0.0	0.0

Fly Ash Air Classification Test # 6

Fine Fraction			Coarse Fraction		
Channel (microns)	Cum. % Passing	Volume % Passing	Channel (microns)	Cum. % Passing	Volume % Passing
			176	100.0	2.7
			125	97.3	3.4
			88	93.8	5.2
			62	88.6	14.7
			44	74.0	14.2
			31	59.7	11.7
22	100.0	0.0	22	48.0	8.5
16	100.0	0.0	16	39.5	12.5
11	100.0	0.2	11	27.0	13.0
7.8	99.8	6.1	7.8	13.9	2.6
5.5	93.7	14.6	5.5	11.3	6.2
3.9	79.1	33.0	3.9	5.1	4.5
2.8	46.1	28.9	2.8	0.6	0.4
1.9	17.1	9.7	1.9	0.2	0.2
1.4	7.5	5.6	1.4	0.0	0.0
0.9	1.9	1.9	0.9	0.0	0.0

Fly Ash Air Classification Test # 7

Fine Fraction			Coarse Fraction		
Channel (microns)	Cum. % Passing	Volume % Passing	Channel (microns)	Cum. % Passing	Volume % Passing
			176	100.0	4.2
			125	95.8	5.2
			88	90.6	8.5
			62	82.2	15.8
			44	66.4	11.7
			31	54.7	11.6
22	100.0	0.0	22	43.1	14.7
16	100.0	1.2	16	28.4	11.5
11	98.8	6.4	11	16.9	9.7
7.8	92.4	16.4	7.8	7.2	2.3
5.5	76.0	22.4	5.5	4.9	1.7
3.9	53.6	22.8	3.9	3.2	2.9
2.8	30.8	18.1	2.8	0.2	0.2
1.9	12.7	7.1	1.9	0.0	0.0
1.4	5.6	4.2	1.4	0.0	0.0
0.9	1.4	1.4	0.9	0.0	0.0

Fly Ash Air Classification Test # 8

Fine Fraction			Coarse Fraction		
Channel (microns)	Cum. % Passing	Volume % Passing	Channel (microns)	Cum. % Passing	Volume % Passing
			176	100.0	2.8
			125	97.2	3.0
			88	94.2	9.0
			62	85.3	15.8
			44	69.4	13.8
			31	55.7	10.6
22	100.0	0.0	22	45.1	13.2
16	100.0	0.0	16	31.9	11.9
11	100.0	0.4	11	19.9	10.3
7.8	99.6	3.1	7.8	9.7	9.7
5.5	96.5	3.5	5.5	0.0	0.0
3.9	93.0	29.5	3.9	0.0	0.0
2.8	63.5	35.7	2.8	0.0	0.0
1.9	27.9	14.5	1.9	0.0	0.0
1.4	13.4	9.4	1.4	0.0	0.0
0.9	3.9	3.9	0.9	0.0	0.0

Fly Ash Air Classification Test # 9

Fine Fraction			Coarse Fraction		
Channel (microns)	Cum. % Passing	Volume % Passing	Channel (microns)	Cum. % Passing	Volume % Passing
			176	100.0	0.0
			125	100.0	0.0
			88	100.0	7.6
			62	92.4	16.7
			44	75.6	12.4
			31	63.2	12.2
22	100.0	0.0	22	51.0	14.6
16	100.0	0.0	16	36.4	13.9
11	100.0	0.1	11	22.5	13.0
7.8	99.9	3.4	7.8	9.6	9.6
5.5	96.6	6.2	5.5	0.0	0.0
3.9	90.4	31.4	3.9	0.0	0.0
2.8	59.0	34.4	2.8	0.0	0.0
1.9	24.7	13.2	1.9	0.0	0.0
1.4	11.5	8.3	1.4	0.0	0.0
0.9	3.3	3.3	0.9	0.0	0.0

Fly Ash Air Classification Test # 10

Fine Fraction			Coarse Fraction		
Channel (microns)	Cum. % Passing	Volume % Passing	Channel (microns)	Cum. % Passing	Volume % Passing
			176	100.0	1.7
			125	98.3	6.6
			88	91.7	9.9
			62	81.8	14.0
			44	67.8	14.7
			31	53.1	13.1
22	100.0	0.0	22	40.0	10.4
16	100.0	1.2	16	29.7	11.7
11	98.8	5.9	11	17.9	10.4
7.8	92.9	15.1	7.8	7.5	0.4
5.5	77.8	20.9	5.5	7.1	2.6
3.9	57.0	23.8	3.9	4.5	4.3
2.8	33.1	19.7	2.8	0.2	0.2
1.9	13.4	7.5	1.9	0.0	0.0
1.4	6.0	4.4	1.4	0.0	0.0
0.9	1.5	1.5	0.9	0.0	0.0

Fly Ash Air Classification Test # 11

Fine Fraction			Coarse Fraction		
Channel (microns)	Cum. % Passing	Volume % Passing	Channel (microns)	Cum. % Passing	Volume % Passing
			176	100.0	1.5
			125	98.5	6.2
			88	92.3	9.4
			62	82.9	14.3
			44	68.6	14.6
			31	54.0	12.7
22	100.0	0.0	22	41.3	12.9
16	100.0	2.8	16	28.4	13.3
11	97.2	8.7	11	15.2	6.0
7.8	88.5	19.5	7.8	9.2	4.2
5.5	69.0	19.7	5.5	5.0	5.0
3.9	49.3	20.1	3.9	0.0	0.0
2.8	29.2	18.3	2.8	0.0	0.0
1.9	10.9	6.3	1.9	0.0	0.0
1.4	4.6	3.6	1.4	0.0	0.0
0.9	1.0	1.0	0.9	0.0	0.0

Fly Ash Air Classification Test # 12

Fine Fraction			Coarse Fraction		
<u>Channel (microns)</u>	<u>Cum. % Passing</u>	<u>Volume % Passing</u>	<u>Channel (microns)</u>	<u>Cum. % Passing</u>	<u>Volume % Passing</u>
350	100.0	0.3			
250	99.7	4.7			
176	95.0	3.2	176	100.0	2.3
125	91.8	0.0	125	97.7	4.4
88	91.8	0.0	88	93.3	12.5
62	91.8	0.0	62	80.8	11.7
44	91.8	0.0	44	69.1	12.7
31	91.8	6.7	31	56.4	15.8
22	85.1	2.5	22	40.6	8.0
16	82.6	0.7	16	32.6	11.6
11	81.9	3.0	11	21.0	12.5
7.8	78.9	11.6	7.8	8.4	0.9
5.5	67.3	17.6	5.5	7.5	3.1
3.9	49.7	21.4	3.9	4.4	4.4
2.8	28.3	17.5	2.8	0.0	0.0
1.9	10.8	6.2	1.9	0.0	0.0
1.4	4.6	3.5	1.4	0.0	0.0
0.9	1.0	1.0	0.9	0.0	0.0